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ORIGINAL ARTICLE

A global productivity and bibliometric analysis of telemedicine and teledermatology publication trends during 1980–2013

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ABSTRACT

Background/Objective: Telemedicine and teledermatology literature has a limited number of bibliometrics reports. We aimed to analyze telemedicine and teledermatology literature using the Institute for Scientific Information Web of Science database.
Methods: The statistical analysis of the documents published during 1980–2013 was performed. We also analyzed the correlations between economical productivities, humanity index, and technological advancement levels and performances of the countries in both fields.
Results: The USA ranked first in the telemedicine field with 3204 publications and 33.8% of the world production followed by the UK and Germany. In the teledermatology field, the USA was the first country again with 206 papers (36%) followed by the UK and Australia (104 and 50 papers, respectively). The most productive countries in telemedicine were Cyprus (30.03), Norway (28.19), and Australia (19.61). Austria ranked first (4.94) in terms of productivity in teledermatology followed by Norway (3.13), New Zealand (2.43), and Australia (2.13). A high correlation was found between number of publications and 2013 gross domestic product values of 60 countries ($r = 0.804$, $p < 0.001$ for telemedicine and $r = 0.721$, $p < 0.001$ for teledermatology). A high correlation was detected between the number of telemedicine publications and gross domestic product per hour worked ($r = 0.712$, $p < 0.001$) although moderate correlation was measured in teledermatology field ($r = 0.558$, $p < 0.05$). We found a significant correlation between number of publications and human development index ($r = 0.779$, $p < 0.001$ for telemedicine and $r = 0.767$, $p < 0.001$ for teledermatology).
Conclusion: Most items have been published from high-income, developed countries. Thus the physicians in undeveloped and developing countries, in which telemedicine and teledermatology applications are crucial to deliver medical care and services, should be encouraged to perform novel studies.

Introduction

Recent developments in technology have made our life easier and faster than ever before. Telemedicine is a convenient application that can improve access to medical care and services that would often not be consistently available in distant rural communities. Teledermatology is a pearl of telemedicine since it has become one of the fastest growing branches of telemedicine via the latest information and digital imaging technology.[1] Although since the 1990s thousands of articles have been published, there has been a limited number of studies performed evaluating the progress and growth of telemedicine and teledermatology literature.[2–4]

Bibliometrics is a discipline that analyzes academic literature or describes patterns of publications in a certain field. The philosophy of science, sociology of scientific knowledge, and history of science are closely related branches to bibliometrics. Bibliometric studies include productivity of authors, countries, growth of literature, and distribution of scientific publications by country or by language.[5] These data help to monitor growth and pattern of a specific field.

The aim of this study was to analyze telemedicine and teledermatology literature using the Thomson Reuters Web of Science (WoS) database. We also investigated whether there were possible correlations between economical productivities, and technological advancement levels and performances in telemedicine and teledermatology in the countries.

Conflicts of interest: The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in this article.

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Table 1 Types of publications on telemedicine and teledermatology.[a]

Type	Topic			
	Telemedicine		Teledermatology	
	No.	%	No.	%
Original article/report	5282	55.8	360	63
Review	479	5.1	41	7.2
Letter	182	1.9	38	6.6
Editorial material	421	4.4	20	3.5
Book chapter	5	0.05	0	0
Book review	15	0.15	0	0
Meeting abstract	595	6.3	65	11.4
Note	5	0.05	0	0
Proceedings paper	2828	29.9	71	12.43
Total	**9465**	**100**	**572**	**100**

[a] Total percentages may exceed 100% because certain items were included in more than one category.

Methods

The data of this study were based on the database of Thomson Reuters WoS (Thomson Reuters, New York, NY, USA). "Telemedicine" and "teledermatology" were used as the keywords to search the WoS database. Documents published in 2014 were excluded. The statistical analysis of the documents published during 1980–2013 was performed. Regression analysis was performed for the statistical evaluation. Correlation was assessed and finalized by Spearman test since data were not normally distributed.[6]

Results

Total number of published items

As the keyword "telemedicine" was used to search articles, the WoS database search retrieved a total of 9465 publications from the beginning of 1980 to the end of 2013. It was found that 55.8% of the total telemedicine publications were original articles followed by proceedings papers (29.9%), meeting abstracts (6.3%), and reviews (5.1%). The WoS database search yielded 572 teledermatology publications and the majority of those were original articles (63%; Table 1).

The top 10 countries were ranked by the number of total indexed publications. Publications reported from England, Northern Ireland, Scotland, and Wales were included under the UK heading. The USA ranked first in the telemedicine field with 3204 publications and 33.8% of the world production. The USA was followed by the UK and Germany (947 papers and 595 papers, respectively; Figure 1). In the teledermatology field, the USA was the first country again with 206 papers (36%) followed by the UK and Australia (104 papers and 50 papers, respectively; Figure 2).

Productivity of the countries

We measured productivity scores of the countries by a simple formula (production numbers/population × 1,000,000) and ranked the countries.[2] The most productive countries in telemedicine were Cyprus (30.03), Norway (28.19), Australia (19.61), and Greece (18.31; Figure 3). Austria ranked first (4.94) in terms of productivity in teledermatology field followed by Norway (3.13), New Zealand (2.43), and Australia (2.13; Figure 4).

Gross domestic product (GDP) measures all final goods and services produced in a country.[7] A high correlation was found between number of publications and 2013 GDP values of 60 countries ($r = 0.804$, $p < 0.001$ for telemedicine and $r = 0.721$, $p < 0.001$ for teledermatology). The USA ranked first in the world in both the number of telemedicine publications (3204 papers) and GDP ($16.72 trillion).[8] GDP per capita is a basic measure of the economic well-being of a country. We measured moderate correlation between the number of publications and 2013 GDP per capita based on purchasing power parity (PPP) values of the countries producing telemedicine and teledermatology publications ($r = 0.651$, $p < 0.05$ for telemedicine and $r = 0.556$, $p < 0.05$ for teledermatology; Table 2). The GDP (PPP) per hour worked is an objective indicator of the productivity of a country.[7] A high correlation was detected between the number of telemedicine publications and GDP (PPP) per hour worked ($r = 0.712$, $p < 0.001$) although moderate correlation was measured in the teledermatology field ($r = 0.558$, $p < 0.05$). We found moderate correlation between number of internet users and number of publications for the countries producing papers in telemedicine and teledermatology ($r = 0.574$, $p < 0.05$ for telemedicine and $r = 0.551$, $p < 0.05$ for teledermatology). Nearly the same correlation was also measured between the number of papers and percentage of individuals using the internet ($r = 0.564$, $p < 0.05$ for telemedicine and $r = 0.569$, $p < 0.05$ for teledermatology). Human development index (HDI) is a combined statistic of education, income, and life expectancy indices and used to rank countries into tiers of human development.[9] We found a significant correlation between number of publications and HDI ($r = 0.779$, $p < 0.001$ for telemedicine and $r = 0.767$, $p < 0.001$ for teledermatology; Table 2).

Progression and prediction of the publications

A significant correlation was found between the year and cumulative number of telemedicine and teledermatology publications as

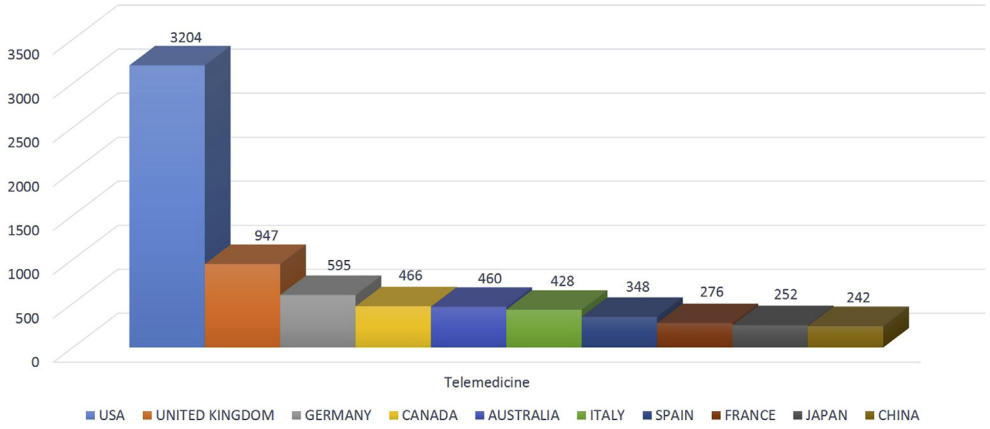

Figure 1 Top 10 countries publishing telemedicine publications by total number of items.

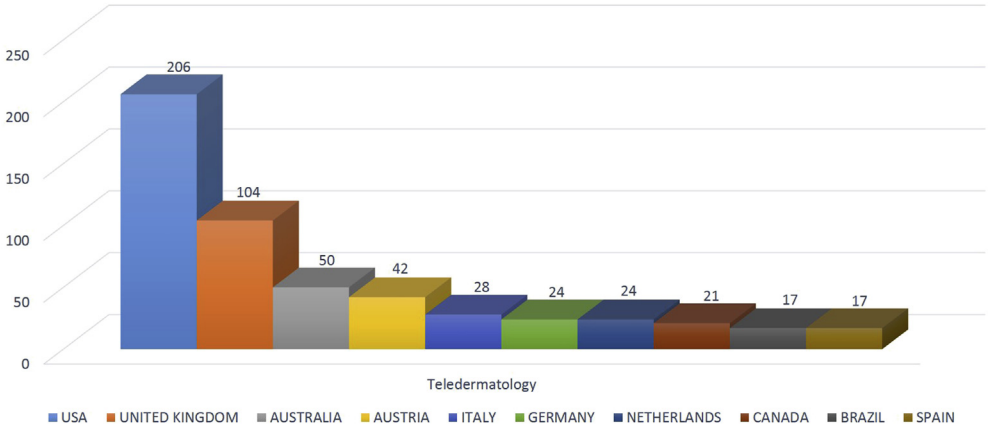

Figure 2 Top 10 countries in teledermatology by total number of publications.

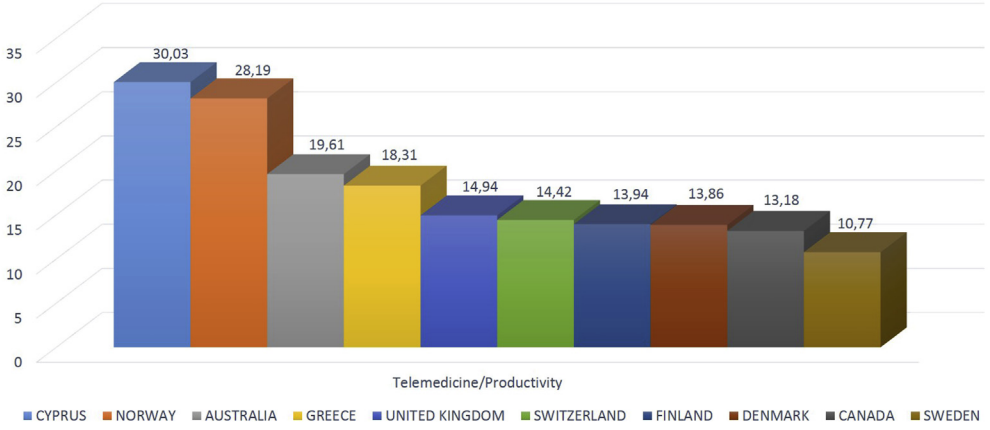

Figure 3 Top 10 countries in productivity in telemedicine field.

shown in Figures 5 and 6 ($r = 0.994$, $p < 0.001$ for telemedicine and $r = 0.995$, $p < 0.001$ for teledermatology). The publication number for 2014 was estimated by using cumulative publication numbers for 1998 and 2013. It could be calculated that estimated publication number will be 797 for telemedicine ($R^2 = 1.000$) and 48 for teledermatology ($R^2 = 0.999$) in 2014.

Discussion

Over the past 3 decades, the number of telemedicine publications has gradually increased. Although a gradual increase of telemedicine publications was present until 2001 (483 documents), a significant fall (18%) was found by 2002 (396 documents). A 19.1% decline was detected between 2009 and 2010, from 741 to 595 documents. As in the previous studies, we determined that the USA ranked first among the countries producing telemedicine publications.[2–4] In terms of the productivity, Northern Ireland ranked first in both fields in our study, although it was not in the most productive countries in previous studies since Northern Ireland and Scotland were included in the UK. Moser et al[2] reported that Norway was the most productive country in telemedicine, although we found it as the third productive in both fields.

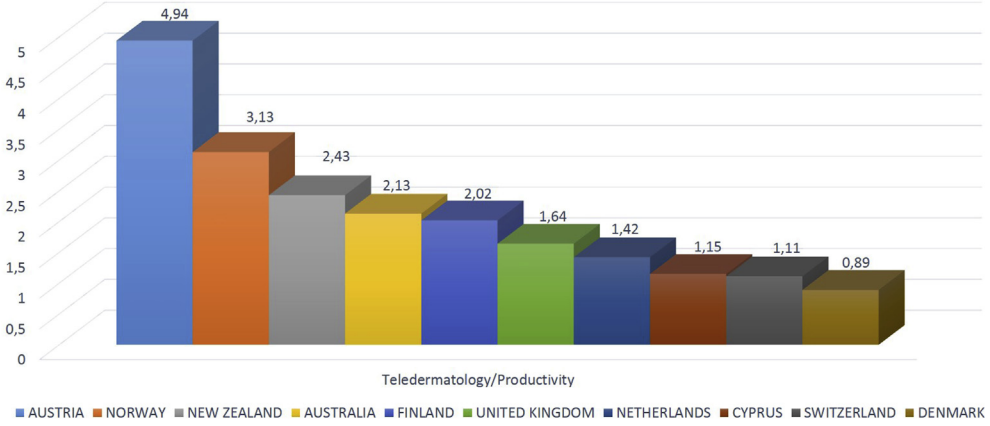

Figure 4 Top 10 countries in productivity in teledermatology field.

Table 2 Correlations between publication numbers and productivity and development indices of countries.

	GDP (PPP) per hour worked	GDP (PPP) per capita	GDP	No. of Internet users	PIUI	HDI
Telemedicine ($n = 60$)	$r = 0.712$ $p < 0.001$*	$r = 0.651$ $p < 0.05$*	$r = 0.804$ $p < 0.001$*	$r = 0.574$ $p < 0.05$*	$r = 0.564$ $p < 0.05$*	$r = 0.779$ $p < 0.001$*
Teledermatology ($n = 60$)	$r = 0.558$ $p < 0.05$*	$r = 0.556$ $p < 0.05$*	$r = 0.721$ $p < 0.001$*	$r = 0.551$ $p < 0.05$*	$r = 0.569$ $p < 0.05$*	$r = 0.767$ $p < 0.001$*

* Statistically significant ($0.00 < r < 0.25$: little if any correlation; $0.26 < r < 0.49$: low correlation; $0.50 < r < 0.69$: moderate correlation; $0.70 < r < 0.89$: high correlation; $0.90 < r < 1.00$: very high correlation).
GDP = gross domestic product; HDI = human development index; PIUI = percentage of individuals using the Internet (according to total population of a country); PPP = purchasing power parity.

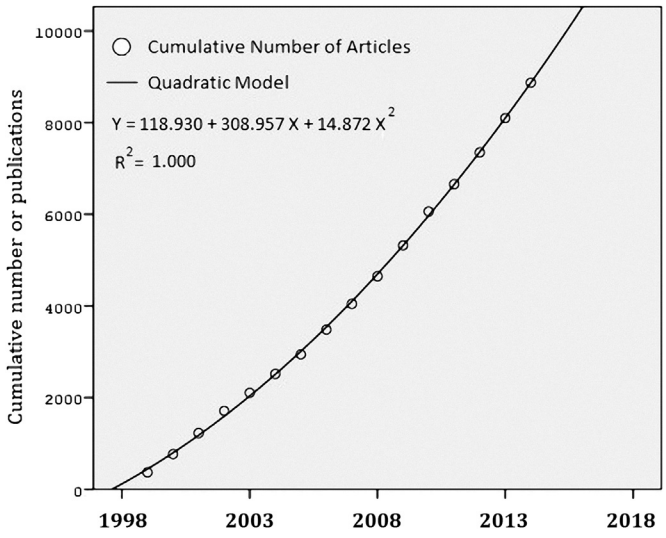

Figure 5 Cumulative number of telemedicine publications by year.

Fatehi and Wootton[3] examined the occurrence of the terms "telemedicine", "telehealth", and "e-health" in the Scopus database and a total of 11,642 documents were found in 2012. They found that "telemedicine" was the most common term with 8028 documents. Moser et al[2] found 4136 documents using the search term "telemedicine" in MEDLINE from 1964 to 2003. They reported significant correlations between publications per million inhabitants and GDP per capita. They also found a significant correlation between number of publications per 1000 inhabitants and HDI.[2] Three indices (GDP, GDP per hour worked, and HDI) created significant correlations in our study.

Our study had some limitations. First, because we used only the WoS database to search publications, we could reach back to 1980. Moser et al[2] could search publications between 1964 and 2003 by using MEDLINE. Fatehi and Wootton[3] reached back to 1972 because the Scopus database that they used covers a wider range of sources than WoS. We also found a smaller number of publications because we did not search databases including more journals than WoS such as MEDLINE, SCOPUS, or Index Copernicus. We preferred to search the WoS database because it is the most reliable service for publications and citations. All the journals included in the WoS database had impact factors. We included only two terms as keywords to prevent the results being incomprehensible. We could not exclude possible duplicates of the same study in the total number of publications. For example, an original article might have been

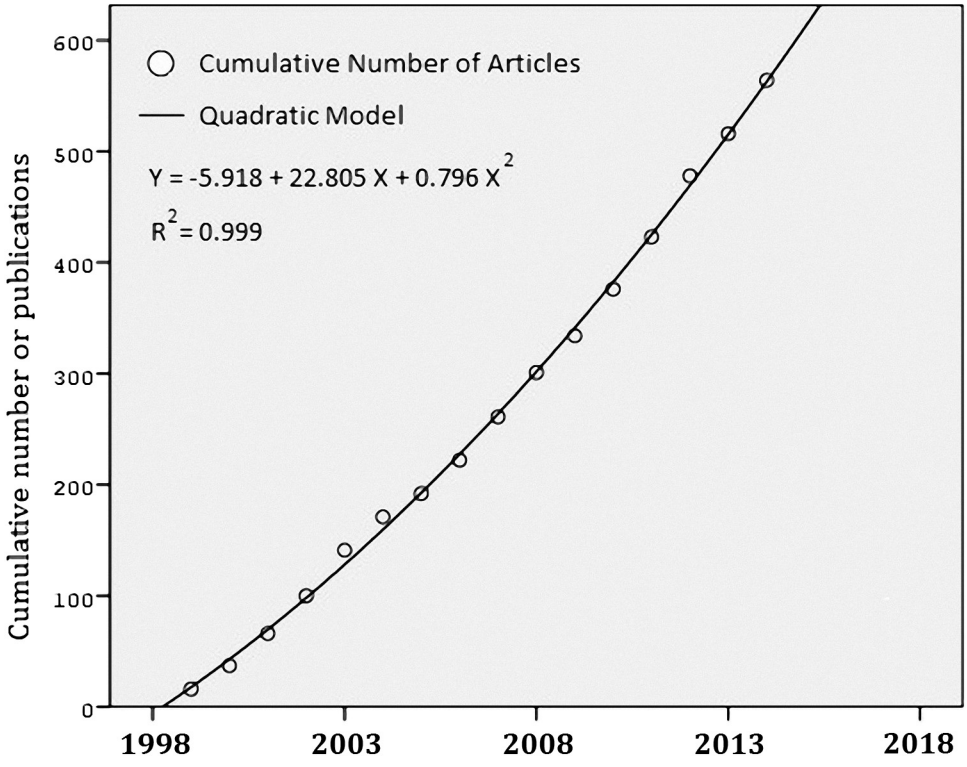

Figure 6 Cumulative number of teledermatology publications by year.

presented as several proceedings and it was not possible to exclude these duplicates.

There are ~8 million medical doctors in the world and the ratio of those to the population by country varies from 1 to 440 per 100,000 people.[10] Although this ratio is 164 physicians per every 100,000 people for the UK, it is only 1.1 for Rwanda.[1] Although telemedicine and teledermatology applications are crucial, waiting time and treatment cost-reducing tools for undeveloped or developing countries where rural/urban physician distribution is a critical problem, most of the publications have been reported from developed countries as detected in our study. Physicians in undeveloped and developing countries should be encouraged to perform studies and to attempt to develop novel modalities in the telemedicine and teledermatology fields. Investments in telecommunication infrastructure should be supported to reduce the cost of telemedicine and teledermatology applications by international organizations in undeveloped countries.

Acknowledgments

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